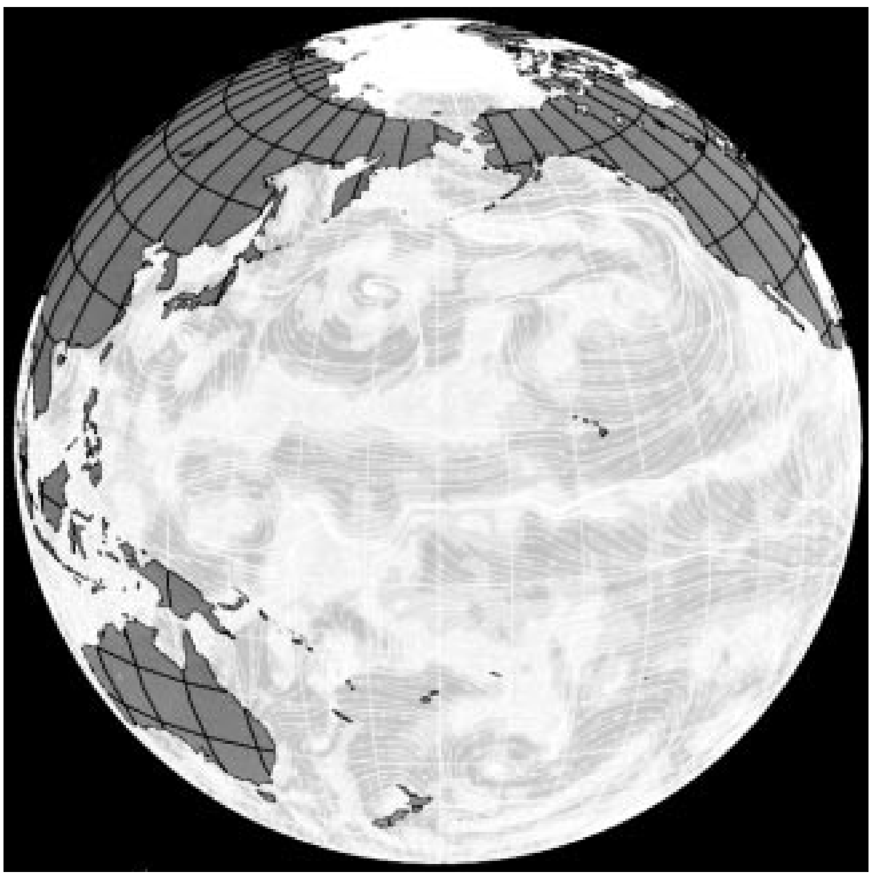
NASA Facts

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109

Oceanography from Space

When the Apollo astronauts looked back at Earth from the Moon, they saw the planet as a bright, blue marble glistening against the vast, black background of space. It was the stark blueness of the oceans in those first space-based images of Earth that struck many viewers. With nearly 70 percent of Earth's surface covered with water, the oceans make a spectacular impression when viewed from space. Today, scientists at NASA's Jet Propulsion Laboratory are using the vantage point of space to study how our oceans work.



NASA Scatterometer (NSCAT) view of the Pacific Ocean

In the past, oceanographers had to study the sea from ships, a process that provided only spotty measurements from fixed locations. Today, several JPL robotic missions and instruments are designed to give oceanographers a panoramic view of Earth. Scientists hope to find out what role the oceans play in global climate and the greenhouse effect and their studies will yield more accurate weather forecasts and predictions of long-term environmental change. All of JPL's current missions are part of NASA's Mission to Planet Earth, and all of the investigations involve some type of international cooperation.

Roots in Seasat

All of JPL's ocean-observing satellites and instruments use some form of radar to study the seas. Radars are useful tools because they can penetrate clouds, they operate in all weather conditions, and they provide their own illumination so they can function day and night.

Seasat was launched in 1978 as a "proof-of-concept" mission to determine if radar remote sensing was valuable for ocean studies. The satellite carried five instruments to measure sea-surface temperature, wind speed, wind direction, the amount of water in the atmosphere, ocean waves and ice fields. Seasat operated for 100 days before an electrical short circuit ended the mission. However, the data collected before the mission stopped proved that accurate measurements of the oceans could be made from space.

Is Sea Level Rising?

Some scientists believe that as carbon dioxide and other emissions are added to our atmosphere, the Earth will get warmer. If this happens, ocean levels may rise due to melting ice and the expansion of ocean water as it warms. Rising ocean levels would make hurricanes and other storms more dangerous. More than half of people in the United States live within 50 miles of a coastline and some entire nations, like Bangladesh and the Netherlands, are at or near sea level.

JPL manages a U.S/French satellite called TOPEX/Poseidon that is currently making the first precise measurements of global sea height.

TOPEX/Poseidon was launched on an Ariane rocket from French Guiana on August 10, 1992. The satellite’s primary science goal is to improve our understanding of how the oceans circulate. Such information allows oceanographers to study the way the oceans transport heat and nutrients and how the oceans interact with weather patterns. TOPEX/Poseidon’s data are being used to understand the ocean's role in global change and to track potentially dangerous phenomenon, such as El Nino.

An El Nino event occurs when there is a change in the normal weather conditions in the equatorial Pacific Ocean. During an El Nino year, a large region of unusually warm water moves across the equator toward South America. Along the way, this warm water alters weather and rainfall patterns, wind directions and even the Jet Stream. The affects of these changed patterns are felt all over the world. Scientists are using space-based data to better predict when El Ninos will occur. In early 1995, oceanographers confirmed that TOPEX/Poseidon had detected a new El Nino condition as it formed in the equatorial Pacific Ocean. This particular event was linked to unusually rainy weather in California and unseasonably warm temperatures in the Northeast United States.

TOPEX/Poseidon uses a radar altimeter to bounce signals off the ocean's surface. The device records the time it takes the signal to return to the satellite and that gives it a precise measurement of the distance between TOPEX/Poseidon and the sea surface. These data are combined with measurements from other instruments that pinpoint the satellite's exact location in space. Every 10 days, scientists are able to produce a complete map of global ocean topography -- the barely perceptible hills and valleys on the sea surface. With knowledge of ocean topography, scientist can then calculate the speed and direction of worldwide ocean currents.

As part of the satellite’s ongoing mission, TOPEX/Poseidon data are being used in the Gulf of Mexico to help scientists and a U.S. oil company study potentially dangerous ocean phenomena, called eddies, that can disrupt off-shore oil drilling. In another application, the precision of the satellite’s ocean measurements has enabled scientists to calculate global tides across all the open oceans, an important step toward monitoring global ocean circulation from space and understanding the complexities of global climate change.

A TOPEX/Poseidon follow-on mission, called Jason 1, is planned for later this decade to continue monitoring ocean surface topography so that scientists can improve their computer models to predict long-term global change.

Winds Over the Oceans

Winds are a driving force for oceanic motions, ranging from small-scale waves to large-scale systems of ocean currents. Winds directly affect the turbulent exchanges of heat, moisture and greenhouse gases between the atmosphere and the ocean. These air-sea exchanges, in turn, determine regional weather patterns and shape global climate.

On August 17, 1996, a JPL instrument called the NASA Scatterometer (NSCAT) was launched onboard the Advanced Earth Observing Satellite (ADEOS) by Japan’s National Space Development Agency (NASDA). The satellite functioned until early 1997. During the mission, NSCAT took 190,000 wind measurements per day, mapping more than 90 percent of the world’s ice free oceans every two days. The instrument providesdmore than 100 times the amount of ocean wind information currently available from ship reports -- and, because NSCAT was a radar instrument, it was capable of taking data day and night, regardless of sunlight or weather conditions.

NSCAT was a scatterometer, meaning that the instrument looks off the side of the satellite, instead of straight down like an altimeter. NSCAT measures the total power returned from its transmitted signal after the radar pulse has struck the ocean's surface. The scatterometer is measuring the roughness of the surface, and consequently, the winds over the surface of the ocean.

Another important part of the NSCAT instrument is the ground system that processes the data. Within two weeks of receiving raw data from the satellite, the ground processing system can determine wind speed and wind direction. This information is used to develop wind-field maps of the ocean. The National Oceanic and Atmospheric Administration (NOAA) is using the NSCAT data in its computer models for predicting weather and storm movements.

NSCAT measurements were combined with other space-based observations, like TOPEX/Poseidon data, to improve our understanding of El Nino and long-term climate change. NSCAT data are also able to pinpoint the location, structure and strength of storms at sea. The instrument's accurate wind information is greatly enhancing overall weather forecasting capabilities.

In addition to changing the way we get our weather forecasts, scatterometer wind observations are of particular interest to other industries. Prior knowledge of winds can enable captains of ocean-going cargo ships to choose routes that avoid heavy seas or high head-winds which slow a ship's progress and increase fuel consumption. Thorough knowledge of the historical wind and wave conditions at any specific location is crucial to the design of off-shore oil drilling platforms. Safe and efficient drilling operations depend upon an accurate understanding of the current sea state and storm warnings. Detailed wind data from scatterometers can also help in the management of commercial seafood crops.

NSCAT will be followed by another JPL scatterometer called SeaWinds that will fly on Japan's ADEOS II satellite in 1999. SeaWinds will have all the capabilities of NSCAT to continue collecting valuable wind data well into the next century. In a major functional change from its predecessor, SeaWinds will use a rotating dish antenna with two radar beams instead of NSCAT's array of six, three-meter long antennas.

Other Platforms

Oceanography was also one of the many disciplines studied by the joint U.S./German/Italian Spaceborne Imaging Radar C/X band Synthetic Aperture Radar that flew on the space shuttle Endeavour in April and October 1994. The relatively low altitude of the shuttle was particularly advantageous for oceanography investigations since the SIR-C/X-SAR radars are more sensitive to ocean features than satellites in higher orbits. Oceanographers are using data from SIR-C/X-SAR to study surface and internal waves and wave/current interactions. In addition, extensive wave energy information was collected over the Southern Ocean by an associated experiment provided by the Johns Hopkins Applied Physics Lab. These data will help scientists study how the Earth's climate is moderated by the ocean. During the second flight, data were also collected in support of a controlled oil spill experiment conducted by Germany in the North Sea that was designed to measure the radar signature of different weights and types of oils. Radar images were also acquired of sea ice in the Weddell Sea.

3-97 MAH